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**Catalog of the Scorpions of the World (1758-1998) by V. Fet, W. D. Sissom, G. Lowe, & M. Braunwalder (New York Entomological Society, 2000: 690 pp.)
Discussion and supplement for 1999 and part of 2000.**

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Introduction

Since the discussion below concerns primarily matters in which my opinion differs from that held by the authors, the reader may get the impression that I am being highly critical of the catalog. Therefore, I would like to emphasize that I consider it a very professionally done significant contribution which fills a basic gap in this branch of arachnology. All the authors are internationally recognized experts and I concur with their handling of the subject matter and their conclusions in a great majority of instances. I also realize that my own list of scorpions with synonymies and distributions (Kovařík, 1998) contains more errors and inaccuracies than this catalog, which has been my primary reason for comparing the two in detail and trying to come up with addenda and corrigenda.

Discussion of some data given in the catalog

Adherence to the International Code of Zoological Nomenclature assures procedural uniformity and unequivocality, i.e. stability in taxonomy. However, I do not see any reason to erect substitute names for invalid names in instances which concern old synonyms exceedingly unlikely to be revived, or for valid species whose names are identical with names today regarded as synonyms of species belonging to other families just because a long time ago these species happened to be placed in the same, often collective genus (e. g. *Scorpio* or *Buthus*), since quite certainly this will not happen again. As an example can serve re-naming *Scorpio maurus tunetanus* Birula, 1910 to *Scorpio maurus punicus* Fet, 2000: 479 (family Scorpionidae) because *Buthus occitanus tunetanus* (Herbst, 1800) (family Buthidae) was originally described in the genus *Scorpio*. I realize the re-naming is in accord with the Code, but fail to comprehend the meaning of this exercise.

Following are several examples of matters in which the data found in the catalog cannot be called erroneous but other points of view are nevertheless possible. However, some of them are minor inaccuracies whose impact is likely to be at worst minimal (no work of this nature and scope can possibly be perfect).

- 1) Differences of opinion on the year of publication if it can no longer influence synonymy.
- 2) Parentheses are incorrectly applied in some instances. For example, *Centruroides chiapanensis tapachulaensis* (Hoffmann, 1932) (see p. 102) was originally described in the genus *Centruroides* as *C. margaritatus tapachulaensis* Hoffmann, 1932 and the author thus should not be in parentheses. The same is true of *Tityus pictus microdon* (Pocock, 1893), new combination (see p. 256), which was described as *Tityus smithi microdon* Pocock, 1893, of *Vachoniochactas lasallei* González-Sponga, 1978, and of some subspecies of the genus *Euscorpius* where parentheses were used in assigning them to different species. Also some endings are incorrect, for instance *Hottentotta conspersus* should be *Hottentotta conspersa* (this error occurs also in my list, Kovařík, 1998: 110).
- 3) A taxon whose type locality is not precisely known, types are lost, and other specimens have not been found although the presumed area of occurrence has been reasonably well collected, is hardly worth upholding as valid. It ought to be either declared a nomen dubium or placed with a question mark in synonymy of a species to which it most likely belongs. As an example can serve *Buthus europaeus tridentatus* P. Franganillo, 1918 from Spain which does not have a precise type locality, no type has been designated, and the entire description consists of less than five lines without any differentiating characters. Vachon (1949) regarded all European populations of *Buthus occitanus* (Amoreux, 1789) as the nominotypical subspecies *B. o. occitanus* (Amoreux, 1789), yet the catalog introduces a new combination *Buthus occitanus tridentatus* (Franganillo, 1918) (see p. 97) without revising the group or mentioning any specimens of this taxon. In light of persisting taxonomic problems with other subspecies of *Buthus occitanus*, I feel the new combination is not warranted and will only complicate future studies of this complex.
- 4) Since the Catalog does not include citations referring to occurrences in individual countries, I refrain from commenting on differences based on my records. They are not frequent and in most instances inconsequential anyway. I would not dare to leave out some of the distributional data the catalog does, e. g. those given by Mello-Leitão, but on the other hand some other deletions were probably appropriate because they concern dubious records often stemming from repeated copying of old and most likely erroneous data.
A special case is the distribution of *Compsobuthus acutecarinatus* (Simon, 1882) that the catalog gives only as Yemen and Oman (p. 125), whereas I have specimens from nearly the entire Arabian peninsula and eastward to Pakistan, which in my opinion belong to this species. However, a truly unequivocal determination will require a revision of the entire genus *Compsobuthus*.
- 5) Valuable is the attempt to resolve problems around a book published by Farzanpay in the Persian language, in which he described the new genera *Olivierus* Farzanpay, 1987, *Razianus* Farzanpay, 1987, *Sassanidothus* Farzanpay, 1987, and the new genus and species *Simonoides farzanpayi* Vachon & Farzanpay, 1987. Publication of new taxa in that language creates a worrisome precedent because of difficulties encountered in translation and the resulting uncertainties in identification of the taxa.
- 6) It is a pity the authors have not used the four-letter system of institutional abbreviations proposed in the work of ARNETT H. R. Jr., SAMUELSON G. A. & NISHIDA G. M. 1993: *The insect and spider collections of the world. Flora & Fauna Handbook No. 11, Second edition*. Gainesville: Sandhill Crane Press, 308 pp. It is a unifying system that makes the work of museum curators and revising authors easier, and it has advantages in computer application.

In the catalog the abbreviations instead vary from two to five letters and are sometimes confusing. For instance, ZMH means the Zoologisches Institut und Zoologisches Museum, Universität Hamburg, Germany, although in other works this abbreviation is used for the Zoological Museum in Helsinki, Finland. Arnett et al. disposed of this inconsistency by using ZMUH for the Zoologisches Institut und Zoologisches Museum, Universität Hamburg and MZHF for the Zoological Museum in Helsinki.

The remarks below concern taxa that present problems or on which I hold a different opinion, but currently available data do not permit to decide which opinion is correct.

Androctonus amoreuxi finitimus (Pocock, 1897) is deemed valid species by Fet & Lowe (2000: 73) without explanation.

The status of ***Buthacus leptochelys*** (Ehrenberg, 1829), ***Buthacus tadmorensis*** (Simon, 1892), and ***Buthacus yotvatensis*** Levy, Amitai & Shulov, 1973 cannot be resolved as the catalog attempts, without the study of types. Based on examination of a relatively large number of specimens, I believe *Buthacus yotvatensis* Levy, Amitai & Shulov, 1973 to be a synonym of *Buthacus tadmorensis* (Simon, 1892).

Centruroides nitidus taino Armas & Marcano Fondeur, 1987 (p. 116) is really best regarded as a subspecies. Santiago-Blay (1993: 6) considers *Centruroides taino* to be a full species (followed by Kovařík, 1998: 108) but does not give supporting reasons.

Some authors regard *Compsobuthus abyssinicus* (Birula, 1903) as a subspecies of *Compsobuthus acutecarinatus* (Birula, 1903). This discrepancy can be resolved only by a revision of the entire genus which is riddled with equivocally defined species-group taxa, among them ***Compsobuthus acutecarinatus arabicus*** Levy, Amitai & Shulov, 1973, ***Compsobuthus acutecarinatus jordanensis*** Levy, Amitai & Shulov, 1973, ***Compsobuthus wernerii carmelitis*** Levy, Amitai & Shulov, 1973, ***Compsobuthus wernerii klaptoczi*** (Birula, 1909), and ***Compsobuthus wernerii longipalpis*** Levy, Amitai & Shulov, 1973.

The catalog gives *Plesiobuthus paradoxus* Pocock, 1900 as valid, although other authors consider it a synonym of ***Liobuthus kessleri*** Birula, 1898 (see pp. 157, 213), primarily because the type has been lost. As long as the type is not found or lectotype designated, it is more appropriate in my opinion to regard *Plesiobuthus paradoxus* Pocock, 1900 as a synonym or nomen dubium.

Considering all the problems encountered with subspecies of *Mesobuthus eupeus* (C. L. Koch, 1839) and the extraordinary variability of this species, I do not think ***Mesobuthus eupeus macmahoni*** (Pocock, 1900) should be elevated to the species status unless it is supported by a revision.

Hadogenes tityrus (Simon, 1888)

= *Hadogenes bifossulatus* Roewer, 1943: 232 (syn. by Newlands, 1980: 72; Kovařík, 1998: 133)

Hadogenes bifossulatus: Fet, 2000: 387

Newlands' (1980) work is an unpublished thesis, however I have seen the holotype of *Hadogenes bifossulatus* Roewer, 1943 deposited at SMFD (a juvenile only about 15 mm long) and agree with his opinion.

One more comment on the genus *Hadogenes*: the catalog (p. 390) gives all seven subspecies of *Hadogenes trichiurus* (Gervais, 1843) as valid with a note that “Kovářik (1998: 133) listed all described subspecies in synonymy to the nominotypic form, without a justification“. The subspecies were synonymized by Newlands (1980: 88 – except the overlooked *Hadogenes trichiurus paucidens* Werner, 1939: 362 = *Hadogenes trichiurus wernerii* Fet, 1997, nom. nov.) in an unpublished work (Revision of the scorpion genus *Hadogenes*. Thesis, Scient. Fac. Science, Potchefstroom, Univ. C. H. E, Transvaal, 188 pp.), and in accordance with nomenclatural rules the validation of his act is provided in my book (Kovářik, 1998: 133). It is the same with subspecies of *Hadogenes troglodytes* (Peters, 1862).

Somewhat inconsistent approach to treating information is evidenced by a synonymy on p. 389, where *Ischnurus hahnii* Peters, 1862 is newly synonymized with *Hadogenes taeniurus* (Thorell, 1876) because „syntypes were recently analyzed by L. Prendini and identified as *H. taeniurus*“, which means the act is based merely on an unpublished communication of unspecified nature.

A list of species and genera described in 1999 and 2000, including two species described in 1998 but not found in the catalog:

Bothriuridae Simon, 1880

Brachistosternus (Ministernus) simoneae Lourenço, 2000: 94

TL: Brésil, Etat de Goiás, Serranópolis; MZSP.

Brazilobothriurus Lourenço & Monod, 2000: 146

Brazilobothriurus pantanalensis Lourenço & Monod, 2000: 146

TL: Brazil, Matto Grosso do Sul, Corumbá, south of Fazenda Salina; MHNG.

Urophonius transandinus Acosta, 1998: 158

TL: Chile, Valparaíso, 33°03'S 71°38'W; ZMUH.

Buthidae C. L. Koch, 1837

Ananteris guyanensis Lourenço & Monod, 1999: 301

TL: French Guyana, Saint Eugène; MHNG.

Ananteris leilae Lourenço, 1999: 94

TL: Colombia, Departamento Chocó, Riosucio-La Gira (20m); ICNC.

Ananteris mariaelenae Lourenço, 1999: 97

TL: Ecuador, Manabi Province, 75-80 km NE of Chone, 90 km W of Santo Domingo; ZMUH.

Babycurus exquisitus Lowe, 2000: 185

TL: Oman, Jabal Shams, Jabal Akhdar, Al Hajar Al Gharbi, 23°14.29'N 57°11.62'E, 1855 m; NHMB.

Cicileus cloudsleythompsoni Lourenço, 1999: 33

TL: Niger, Dao Timni, 260 km N of Bilma; ZMUH.

Compsobuthus simoni Lourenço, 1999: 91

TL: Niger, Birni Nkonni; ZMUH.

Compsobuthus williamsi Lourenço, 1999: 87

TL: Morocco, between Erfoud and Ouarzazate (30° 42' N - 5° 48' W); ZMUH.

Congobuthus Lourenço, 1999: 188

Congobuthus fagei Lourenço, 1999: 188

TL: Congo, Londina-Niadi; MNHN.

Egyptobuthus Lourenço, 1999: 591

Egyptobuthus vaissadei Lourenço, 1999: 595

TL Egypte, région nord du Sinai, proche des côtes de la Mer Rouge; MHNG.

Grosphus intertidalis Lourenço, 1999: 135

TL: Madagascar, Province of Toliara, 3.5 km north of Tulear; ZMUH

Lychas ceylonensis Lourenço & Huber, 1999: 23

TL: Sri Lanka, Girital, near to a freshwater lake; ZMUH.

Microtityus starri Lourenço & Huber, 1999

TL: Trinidad and Tobago, Little Tobago, south west part; MHNG.

Paraorthochirus kasparki Lourenço & Huber, 2000: 141

TL: Oman, Muscat Area, Ras Al Hamra; MNHN.

Paraorthochirus kinzelbachi Lourenço & Huber, 2000: 139

TL: Oman, Wadi Tayin, North of Ibra; MNHN.

Tityobuthus ivohibe Lourenço & Goodman, 1999: 476

TL: Madagascar, Province de Fianarantsoa, exterior northern limit of Réserve Spéciale d'Ivohibe, along Hefitany river, 7,5 km ENE Ivohibe, 22° 28,2'S – 46° 57,6'E (900 m); FMNH.

Tityopsis aliciae Armas & Frías, 1998: 46

TL: Tehuantepec, Oaxaca, Mexico; CNAC.

Tityus florezi Lourenço, 2000: 454

TL: Colombia, Dept Tolima, Mariquita, Bremen (300 m); ICNC.

Tityus gaffini Lourenço, 2000: 449

TL: Colombia, Dept Vichada, Cro. Gaviotas (180 m); ICNC.

Tityus erikae Lourenço, 1999: 1

TL: Colombia, Dept. Cesar, Chimichagua; ICNC.

Tityus prancei Lourenço, 2000: 452

TL: Colombia, Dept Cesar, La Jagua de Ibirico (9°35'5"N - 73°9'45"W), Quebrada el Indio (520 m); ICNC.

Chaerilidae Pocock, 1893

Chaerilus petrzekai Kovařík, 2000: 48

TL: **Vietnam**, 80 km NNE Saigon, prov Dong Nai, valley Ma Da, Tri An dam; FKCP.

Chaerilus tichyi Kovařík, 2000: 60

TL: Malaysia, Pahang, Tioman Island, Kampong Gentling; FKCP.

Chaerilus tryznai Kovařík, 2000: 65

TL: China (Tibet), Bomi env. 29°52' N, 95°45'E, mixed forest; FKCP.

Chactidae Pocock, 1893

Chactas ozendai Lourenço, 1999: 127

TL: Colombia, Department of Antioquia, Angelopolis, 1860 m; ZMUH.

Scorpiopidae Kraepelin, 1905

Scorpiops braunwalderi Kovařík, 2000: 170

TL: India, Chakrata; FKCP.

Scorpiops dastychi Kovařík, 2000: 170

TL: India, Himalaya, Molta; ZMUH.

Scorpiops feti Kovařík, 2000: 174

TL: India, Sikkim; ZMUH.

Scorpiops margerisonae Kovařík, 2000: 189

TL: China (Tibet); FKCP.

Scorpiops problematicus Kovařík, 2000: 194

TL: Thailand, prov. Chiang Mai, Doi Pui mt., 18°49'N–98°54'E; FKCP.

Scorpiops sejnai Kovařík, 2000: 195

TL: Vietnam, Bach-ma Nat. Park, 1200 m, 16°10' N–107°54' E; FKCP.

Hadogenidae Lourenço, 1999***Hadogenes angolensis*** Lourenço, 1999: 932

TL: Angola, Région de l'Huila, «Fazenda Bumbo» près de Capangombe (15°10'S - 13°09'E); MHNG.

Scorpionidae Latreille, 1802***Pandinus (Pandinops) pococki*** Kovařík, 2000: 3

TL: Somalia, Geriban env., 09°20'N 48°09'E; FKCP.

Abbreviations:

TL = Type locality and depository

CNAC = Instituto de Biología, Universidad Nacional Autónoma de México, Mexico

FKCP = František Kovařík Collection, Praha, Czech Republic

FMNH = Field Museum of Natural History, Chicago, Illinois, USA

ICNC = Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogota, Colombia

MHNG = Museum d'Histoire naturelle, Geneve, Geneva, Switzerland

MNHN = Muséum National d'Histoire Naturelle, Paris, France

MZSP = Museu de Zoologia da Universidade de São Paulo, Brazil

NHMB = Naturhistorisches Museum, Basel, Switzerland

ZMUH = Zoologisches Institut und Zoologisches Museum, Universität Hamburg, Germany

Changes published in 1999 and 2000:

For easy orientation, the names given in the catalog are in boldface.

Buthidae C. L. Koch, 1837***Caribetityus*** Lourenço, 1999: 136***Caribetityus elii*** (Armas & Marcato Fondur, 1992)*Tityus elii* Armas & Marcato Fondur, 1992: 22; Fet & Lowe, 2000: 243*Caribetityus elii*: Lourenço, 1999: 136***Caribetityus quisqueyanus*** (Armas, 1982)*Tityus quisqueyanus* Armas, 1982: 13; Fet & Lowe, 2000: 258*Caribetityus quisqueyanus*: Lourenço, 1999: 138***Centruroides baergi*** Hoffmann, 1932*Centruroides nigroviratus baergi* Hoffmann, 1932: 354; Fet & Lowe, 2000: 115*Centruroides baergi*: Armas & Martín-Frías, 1999: 31***Centruroides meisei*** Hoffmann, 1939*Centruroides elegans meisei*: Fet & Lowe, 2000: 103*Centruroides meisei*: Armas & Martín-Frías, 1999: 33***Hottentotta hendersoni*** (Pocock, 1900)*Mesobuthus hendersoni*: Fet & Lowe, 2000: 177*Hottentotta hendersoni*: Kovařík, 1999: 292***Hottentotta pachyura*** (Pocock, 1897)*Mesobuthus pachyurus*: Fet & Lowe, 2000: 178*Hottentotta pachyurus*: Kovařík, 1999: 292***Hottentotta rugiscutis*** (Pocock, 1897)

= *Hemibuthus kraepelini* Roewer, 1943: 213 (syn. by Kovařík, 1999: 291)

Mesobuthus rugiscutis: Fet & Lowe, 2000: 178

Hottentotta (?) *kraepelini*: Fet & Lowe, 2000: 141

Hottentotta rugiscutis: Kovařík, 1999: 291

Hottentotta tamula (Fabricius, 1798)

Mesobuthus tamulus: Fet & Lowe, 2000: 179

Hottentotta tamulus: Kovařík, 1999: 292

Hottentotta trilineata (Peters, 1862)

Hottentotta trilineatus: Fet & Lowe, 2000: 144

= *Buthus eminii* Pocock, 1890: 98 **Syn. n.**

Hottentotta eminii: Fet & Lowe, 2000: 137

Remark: I am currently studying the genus *Hottentotta* and preparing a key to all the species. So far, I have published a key to Indian species (Kovařík, 1999: 291-293) and list those which belong in *Hottentotta*, whereas in the catalog they are placed in *Mesobuthus*. *Hemibuthus kraepelini* Roewer, 1943, which based on examination of the type I synonymized with *Hottentotta rugiscutis* (Pocock, 1897), appears in the catalog as *Hottentotta* (?) *kraepelini* (Roewer, 1943). I also examined the type of *Hottentotta eminii* (Pocock, 1890) and *Hottentotta polysticta* (Pocock, 1896). Whereas *Hottentotta polysticta* is definitely valid and very different from *Hottentotta trilineata* (Peters, 1862), *Hottentotta eminii* is a synonym of *Hottentotta trilineata* (Peters, 1862).

Tityus stigmurus (Thorell, 1876)

Tityus stigmurus: Fet & Lowe, 2000: 262; Lourenço & Cloudsley-Thompson, 1999: 154

= *Tityus serrulatus* Lutz & Mello, 1922; Fet & Lowe, 2000: 260 (syn. by Lourenço & Cloudsley-Thompson, 1999: 154)

= *Tityus lamottei* Lourenço, 1981; Fet & Lowe, 2000: 248 (syn. by Lourenço & Cloudsley-Thompson, 1999: 154)

Tityus paraensis Kraepelin, 1896

Tityus paraensis: Fet & Lowe, 2000: 253

= *Tityus piceus* Caporiacco, 1947: 20; Fet & Lowe, 2000: 255 (syn. by Kovařík, 2000: 463 under *Tityus cambridgei*)

Chaerilidae Pocock, 1893

Chaerilus pictus (Pocock, 1890)

Chaerilus pictus: Fet, 2000: 327; Kovařík, 2000: 53

= *Chaerilus gemmifer* Pocock, 1894: 81; Fet, 2000: 326 (syn. by Kovařík, 2000: 53)

Chaerilus rectimanus Pocock, 1899

Chaerilus rectimanus Pocock, 1899: 418; Kovařík, 2000: 54.

Chaerilus celebensis: Fet, 2000: 325

Chaerilus truncatus Karsch, 1879

Chaerilus truncatus Karsch, 1879: 108; Fet, 2000: 327; Kovařík, 2000: 62

= *Chaerilus granosus* Pocock, 1900: 56; Fet, 2000: 326 (syn. by Kovařík, 2000: 63)

= *Chaerilus anthracinus* Pocock, 1900: 57; Fet, 2000: 324 (syn. by Kovařík, 2000: 63)

= *Chaerilus anthracinus rufescens* Pocock, 1900: 57; Fet, 2000: 324 (syn. by Kovařík, 2000: 63)

? = *Chaerilus granifrons* Kraepelin, 1913: 147; Fet, 2000: 326 (syn. by Kovařík, 2000: 63)

= *Chaerilus hirsti* Kraepelin, 1913: 150; Fet, 2000: 326 (syn. by Kovařík, 2000: 63)

Chaerilus variegatus Simon, 1877

Chaerilus variegatus Simon, 1877: 239; Fet, 2000: 328; Kovařík, 2000: 66.

= ? *Chaerilus borneensis* Simon, 1880: 379; Fet, 2000: 325 (syn. by Kovařík, 2000: 67)
 = *Chelomachus birmanicus* Thorell, 1889: 584; Kovařík, 2000: 67.
Chaerilus birmanicus: Fet, 2000: 324
 = *Chaerilus variegatus nigricolor* Pocock, 1899: 419; Fet, 2000: 328 (syn. by Kovařík, 2000: 67)

Chactidae Pocock, 1893

Brotheas granimanus Pocock, 1898

Brotheas granimanus: Sissom, 2000: 298; Kovařík, 1999: 464
 = *Broteochactas magnus* Caporiacco, 1947: 20 (this name does not appear in the catalog) (syn. by Kovařík, 1999: 464)

Chactas major Kraepelin, 1912;

Chactas lepturus major Kraepelin, 1912: 67; Kraepelin, 1914: 25 (redescription)

Chactas lepturus: Sissom, 2000: 303

Chactas major: Lourenço, 1999: 127

Scorpiopidae Kraepelin, 1905

Scorpiops Peters, 1862: 510

= *Scorpiops (Euscorpiops)* Vachon, 1980 (syn. by Kovařík, 2000: 164)

Euscorpiops: Fet, 2000: 488

Scorpiops: Kovařík, 2000: 163

Scorpiops hardwickii (Gervais, 1843)

Scorpiops hardwickii: Fet, 2000: 492; Kovařík, 2000: 175

= *Scorpiops affinis* Kraepelin, 1898: 44; Fet, 2000: 491 (syn. by Kovařík, 2000: 175)

= *Scorpiops crassimanus* Pocock, 1899: 267; Fet, 2000: 491 (syn. by Kovařík, 2000: 175)

= *Scorpiops insculptus* Pocock, 1900: 68; Fet, 2000: 492 (syn. by Kovařík, 2000: 175)

Scorpiops jendeki Kovařík, 1994

Scorpiops (Scorpiops) hardwickei jendeki Kovařík, 1994: 62.

Scorpiops hardwickii jendeki: Fet, 2000: 492

Scorpiops jendeki: Kovařík, 2000: 180

Scorpiops lindbergi Vachon, 1980

Scorpiops (Euscorpiops) lindbergi Vachon, 1980: 155

Euscorpiops lindbergi: Fet, 2000: 489

Scorpiops lindbergi: Kovařík, 2000: 186

= *Scorpiops kraepelini* Lourenço, 1998: 246; Fet, 2000: 493 (syn. by Kovařík, 2000: 186)

Scorpiops petersii Pocock, 1893

Scorpiops petersii Pocock, 1893: 323; Fet, 2000: 494; Kovařík, 2000: 192

= ? *Scorpiops petersi von-wicki* Birula, 1913: 417 (syn. by Kovařík, 2000: 192)

Scorpiops petersii vonwicki: Fet, 2000: 494

Scorpionidae Latreille, 1802

Pandinus (Pandinops) bellicosus (L. Koch, 1875)

Pandinus (Pandinurus) bellicosus: Fet, 2000: 470

Pandinus (Pandinops) bellicosus: Kovařík, 2000: 4

= *Pandinus pugillator* Pocock, 1900: 52 (syn. by Kovařík, 2000: 3)

Pandinus (Pandinops) pugilator Fet, 2000: 469

Ischnuridae Simon, 1879

Hormiops Fage, 1933

Hormiops Fage, 1933: 30; Lourenço & Monod, 1999: 338; Kovařík, 2000: 57

Liocheles: Fet, 2000: 395

Hormiops davidovi Fage, 1933

Hormiops davidovi Fage, 1933: 32; Lourenço & Monod, 1999: 343; Kovařík, 2000: 57

? *Liocheles australasiae*: Fet, 2000: 396

Iomachus politus Pocock, 1896

Iomachus politus Pocock, 1896: 317; Fet, 2000: 394

= *Iomachus borana* Caporiacco, 1939: 307 (syn. by Kovařík, 2000: 464)

Iomachus borana: Fet, 2000: 393

Urodacidae Pocock, 1893

Urodacinae: Fet, 2000: 480

Urodacidae: Lourenço, 2000: 25

Le Xuan Hue, Pham Quynh Mai, Pham Dinh Sac & Ngo Thi Cat (1998: 7) list *Isometrus basilicus* from Vietnam. I believe it in reality is ***Isometrus (Reddyanus) vittatus*** Pocock, 1900, which was found in Vietnam already by Fage (1933: 28) and three specimens of which are in my own collection (**Vietnam**, prov. Dong Nai, 80 km NNE Saigon, valley Ma Da, Tri An dam, 1FA, 27.IV.1996, 1ME1MA, III.1998, leg. K. Petrželka, FKCP).

Literature not cited in the catalog:

Similarly to Braunwalder, I try to select works relating to taxonomy and/or faunistics.

ACOSTA L. E. 1985: Redescrpcion de *Urophonius achalensis* Abalos y Hominal, 1974 (Scorpiones, Bothriuridae). *Physis, secc. C* **43(104)**: 5-12.

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A Comparative Morphological Study of the Pectines of three Scorpion species (Scorpionida, Buthidae) from Assiut, Egypt

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Abstract

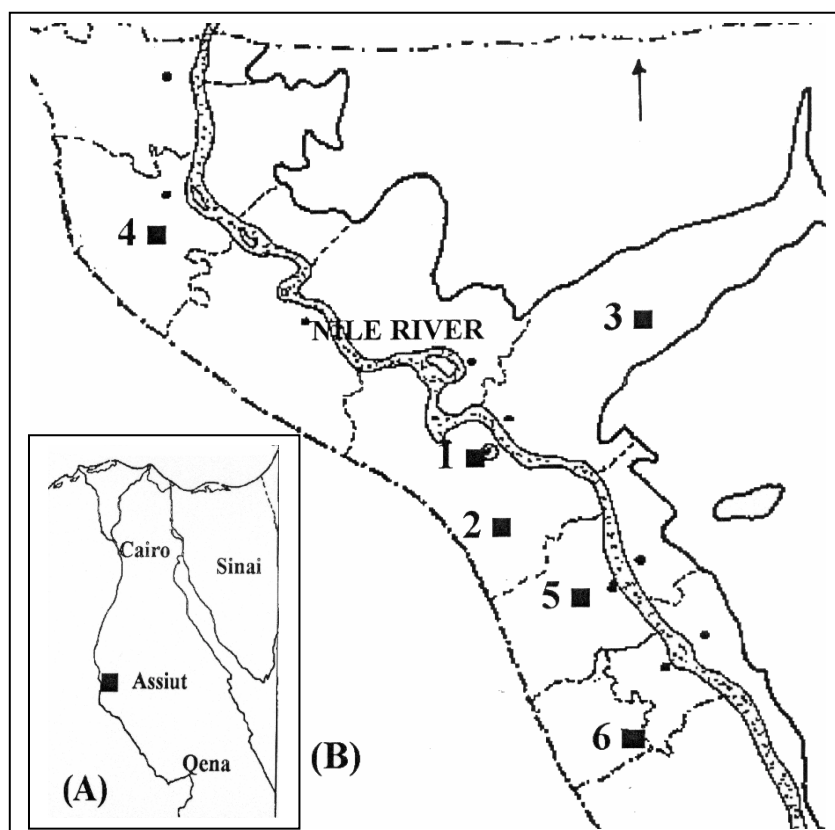
The pectines of three scorpion species from Assiut governorate, belonging to family Buthidae: *Leiurus quinquestriatus*, *Compsobuthus werneri* and *Orthochirus innesi* are studied. They consist of three marginal lamellae, a variable number of median lamellae, fulcra and pectinal teeth. They have the same number of marginal lamellae but with different numbers of median lamellae. Morphological differences of the pectines are found among species and also as sexual dimorphism. These differences are in the number and shape of pectinal teeth, numbers of fulcra, trichobothria and peg sensilla. In *L. quinquestriatus* sexual dimorphism in the pecten is more pronounced than in *C. werneri*. The morphological characters of pectinal teeth of the studied species indicated, that the pectines of *L. quinquestriatus* and *C. werneri* are closer in shape than that of *O. innesi*.

Introduction

The scorpion is one of the oldest and most common animals in the world, but it had received little attention from the biological point of view. In Egypt, most of works dealt with the toxicity of its venom, and very few researches dealt with its histology (Abd-El-Wahab, 1952; Khalil *et al.*, 1983a & b, 1985 and El-Bakary, 1990 & 1998), systematics and ecology (El-Hennawy, 1987, 1991 & 1992 and Moustafa, 1988) and physiology (El-Bakary, 1986).

Pectines of the scorpions are paired ventral lateral appendages. These appendages are unique to the scorpions and appear to be important in substrate recognition (Polis and Sissom, 1990) whose primary functions seem to be as contact chemoreceptors (Gaffin and Brownell, 1997) and mechanoreceptors (Hjelle, 1990). Behavioural observation of scorpions supports the assumption that they are important for discriminating surface texture (Abushama, 1964; Carthy, 1966 & 1968; Boyden, 1978) and mate identification (Gaffin and Brownell, 1992) while Swoveland (1978) suggested three functions: habitat selection, proprioception, and chemoreception.

Although scorpions' stings occur with high frequency in Upper Egypt, the accurate number of scorpion species in Assiut governorate is still unknown. In order to classify the scorpion species, that inhabit this area, and because pecten is a characteristic organ for the scorpion (Savory, 1977) with a taxonomic importance (Polis, 1990 and Brown, 1996), a comparative study of pectines among recorded species was achieved using light and scanning electron microscopes.



Map 1. A. Partial map of Egypt showing the over-all position of Assiut area.
B. Detailed map of Assiut Governorate showing the scorpions collecting sites:
 1- Assiut city 2- Drunka and El Zawia 3- Wady El Assiuty
 4- Al Qusiyah 5- Abu Tig 6- El Ghanaim

Material and Methods

Field collecting of scorpions was conducted in six different sites covering different ecological and geographical regions of Assiut governorate (Map 1 B).

Collecting is achieved by using portable Ultra Violet lanterns under which scorpions fluoresce most bright at dark nights when exposed to a near-ultraviolet light, radiating in range of 320-400 nm, the so called black light technique (Stahnke, 1972). Scorpions were also collected during daytime by searching under rocks and other surface debris (rock rolling) and location of burrows followed by excavation of the inhabitants (Williams, 1968). Only animals judged to be reproductively active adults were used in this study.

In the laboratory, each scorpion was housed in a separate and suitable plastic container in order to avoid cannibalism. Scorpions were provided every week by water and fed with insects especially crickets, roaches, moths and flies.

A simplified key to Egyptian scorpions made by El-Hennawy (1987) was used to classify the recorded species.

For scanning electron microscopy, scorpions were killed by freezing. Subsequently, pectines from different species were cut quickly with a sharp razor and removed using fine forceps under a dissecting microscope. Specimens were fixed in cold 5% glutaraldehyde for 24 hours. The material was washed with 0.1 M sodium cacodylate buffer (pH 7.4) three times, 15 minutes for each, and then treated with osmic acid for 2 hours. Washing three times with buffer was repeated again, then the material was dehydrated through a graded ethanol series, then dried at 30° C for 30 minutes. After complete drying the material was mounted on holders with silver paint and coated with a layer of gold under vacuum. Specimens were investigated using JEOL JSM-540 LV scanning electron microscope at 15 K volt. Microphotographs were taken with different magnifications and analyzed.

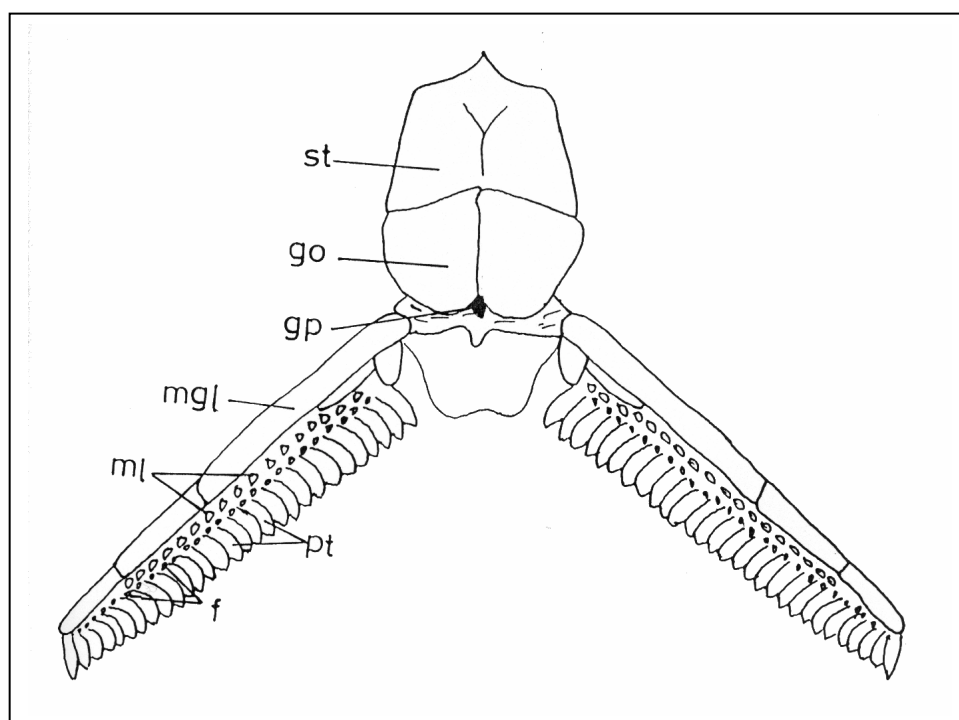


Fig.1 Diagrammatic representation showing structure of the scorpion pecten: **f** = fulcra, **go** = genital operculum, **gp** = genital papillae, **mgl** = marginal lamellae, **ml** = median lamellae, **pt** = pectinal teeth, **st** = sternum.

Results

The collected scorpions are belonging to three different species from family Buthidae. These species are *Leiurus quinquestriatus* (Hemprich & Ehrenberg, 1829), *Compsobuthus wernerii* (Birula, 1908) and *Orthochirus innesi* Simon, 1910. *L. quinquestriatus* is the most common species since it represents 73% of total number of the collected scorpions. The sex ratio relative abundance between males and females of this species is 1: 1.95, respectively. The second species, *C. wernerii*, represents about 20% of the collected scorpion fauna, and the percentage between males and females is 1: 1.78, respectively. The third species *O. innesi* represents only 7% of the collected scorpion specimens, which were only females.

The external morphology of the pectines of the studied species revealed that, each pecten consists of: an outer marginal lamellae, median lamellae and a number of pectinal teeth which are inserted by fulcra, which in turn are attached to the median and outer lamellae (Fig. 1). The outer marginal lamellae are formed of a fixed number of segments, usually three, for all the studied species. The median lamellae are formed of number of segments, which differ among different species, but their number is the same for both male and female of the same species. The fulcra are semicircular pieces attached to median and outer lamellae from one side while the other one is attached to the pectinal teeth. Sensory hairs, about 1 mm long, were found in all hirsute parts but mainly covering the pecten. These hairs, the trichobothria, which are carried by the fulcra, differ in number between males and females within the same species. Males always have a greater number. The pectinal teeth numbers are also varied between sexes within the same species, males always have larger counts. Pectinal teeth shape and number are varied between different species.

Details of the morphological characters of pectines of the three studied scorpion species were studied with various magnification powers by scanning electron microscope (SEM). The numbers of marginal and median lamellae, fulcra, pectinal teeth and trichobothria were counted (Table 1). The SEM revealed the presence of a great number of truncated setal forms, called peg sensilla, on the surfaces of the pectinal teeth. The number of these peg sensilla on each tooth differs among different species, and apparently differs between male and female. Each peg sensillum is a truncated setal form, being “blunt-ended”, mounted into a pit in the cuticle, and its tip is perforated by a slit

Table (1): Comparison of general morphological characters of pectines of three scorpion species by using light and scanning electron microscopes.

Species		<i>L. quinquestriatus</i>		<i>C. wernerii</i>		<i>O. innesi</i>
		♂	♀	♂	♀	♀
Marginal lamellae		3	3	3	3	3
Median lamellae		8	8	7	7	7
Fulcra	Shape	Semicircular	Semicircular	Semicircular	Semicircular	Semicircular
	Number	34-36	26-29	17-21	15-17	13-14
	T/f	5-6	2-3	2-3	2	2-3
Pectinal teeth (denticles)	Shape	Triangular	Triangular	Triangular	Triangular	Elliptical
	Number	35-36	27-30	18-22	16-18	14-15
	Ps/d	1000-1200	560-650	400-450	200-250	300-350

T/f = Number of trichobothria / fulcrum, Ps/d = Number of peg sensilla / denticle

The morphological characters of pectines of *Leiurus quinquestriatus*

A- Male pecten:

The pecten is consisting of three marginal lamellae, eight median lamellae and a row of 34-35 semicircular fulcra (Fig. 2A). Each fulcrum bears 5-6 trichobothria (Fig. 4A), and a row of 35-36 triangular denticles or pectinal teeth. Each denticle bears 1000-1200 peg sensilla (Fig. 5A), 3.5 μm in diameter and 3.5 μm long. Its slit diameter is 1.8 μm (Table 1 & Fig. 6A).

B- Female pecten:

The pecten consists of three marginal lamellae, eight median lamellae, and a row of 26-29 semicircular fulcra (Fig. 3A). Each fulcrum bears numbers of trichobothria

(Fig. 4B), usually 2-3, and a row of 27-30 triangular denticles or pectinal teeth. Each denticle bears 560-650 peg sensilla (Fig. 5B), which are $2.3\ \mu\text{m}$ in diameter and $2.1\ \mu\text{m}$ long. The slit of the tip of each peg sensillum is $1.0\ \mu\text{m}$ in diameter (Table 1 & Fig. 6B).

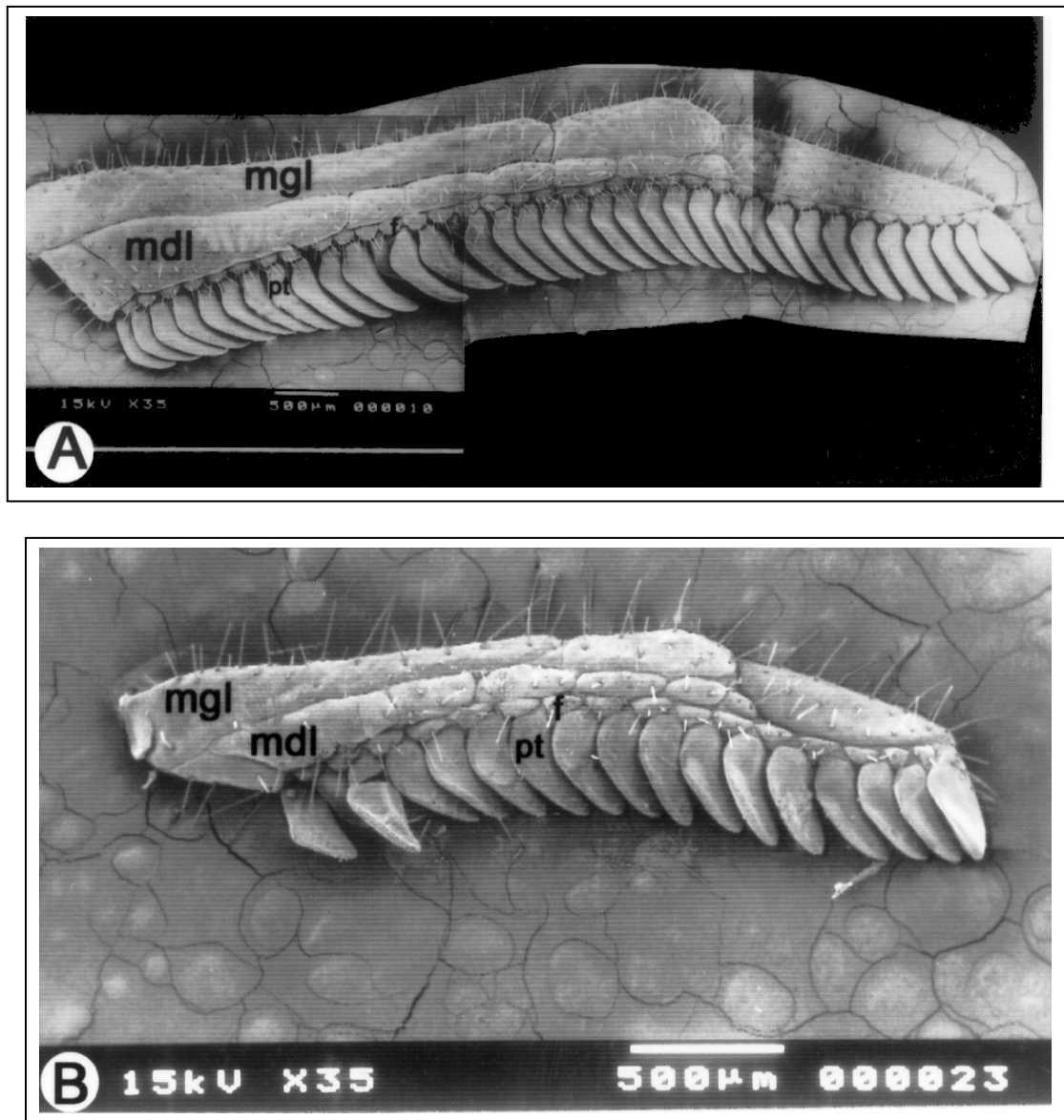


Fig. 2: Scanning electron micrographs showing general morphology of male pectines: **A.** *Leiurus quinquestriatus* (reconstructed). **B.** *Compsobuthus weneri*
f = fulcrum, **mgl** = marginal lamellae, **mdl** = median lamellae, **pt** = pectinal teeth.

Morphological characters of pectines of *Compsobuthus weneri*

A- Male pecten:

The pecten of male *C. weneri* (Fig. 2B) has marginal lamellae with three segments like other species, but the median lamellae are only seven, fulcrum are a row of 17-21 semicircular pieces. Each fulcrum bears a number of trichobothria (Fig. 4C), usually 2-3, and a row of 18-22 triangular denticles or pectinal teeth. Each denticle bears 400-450 peg sensilla (Fig. 5C). The peg sensillum is $2.5\ \mu\text{m}$ in diameter and $2.1\ \mu\text{m}$ long. The slit of the tip of each peg sensillum is $1.2\ \mu\text{m}$ in diameter (Table 1 & Fig. 6C).

B- Female pecten:

Each pecten consists of three marginal lamellae, seven median lamellae and a row of 15-17 semicircular fulcra (Fig. 3B). Each fulcrum bears a number of trichobothria (Fig. 4D), usually 2, and a row of 16-18 triangular denticles or pectinal teeth. Each denticle bears 200-250 peg sensilla (Fig. 5D). Each sensillum is 2.4 μm in diameter and 2.2 μm long, mounted in a cylindrical base 3.3 μm inserted into a pit in the cuticle. The tip of each peg sensillum is perforated by a slit of 1.6 μm in diameter (Table 1 & Fig. 6D).

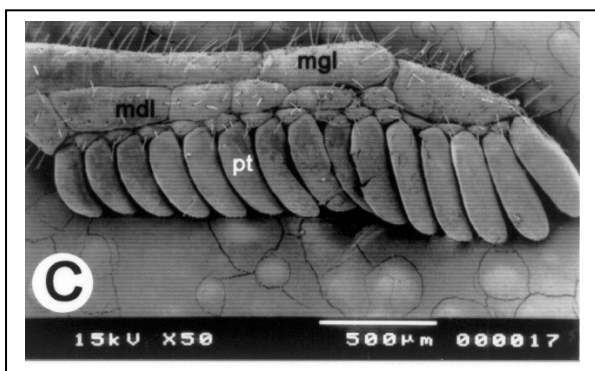
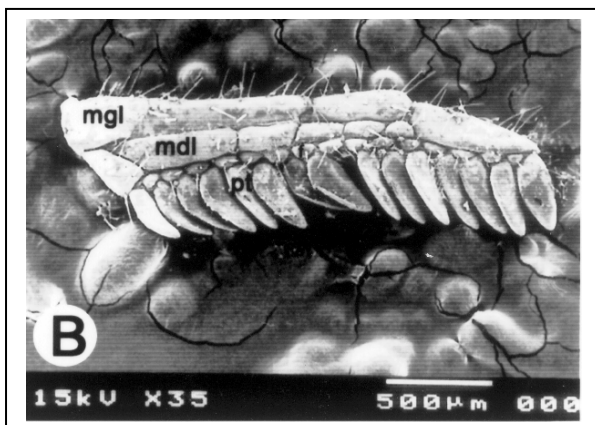
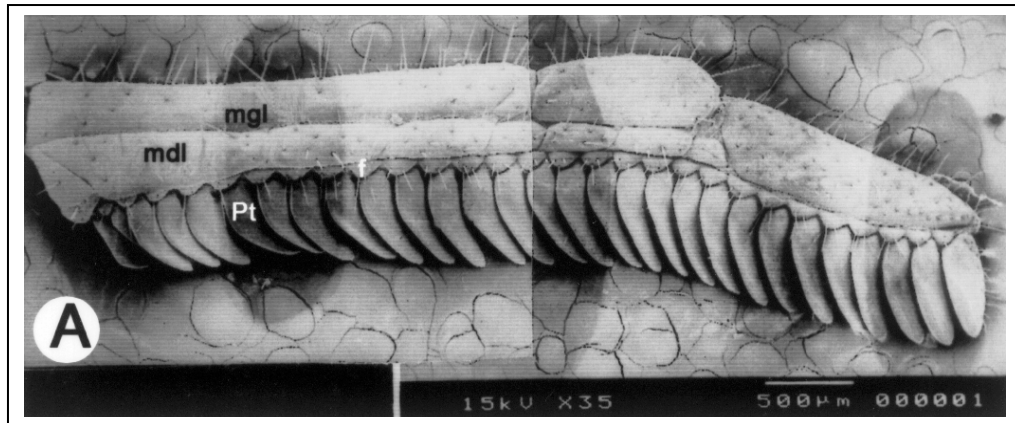


Fig. 3: Scanning electron micrographs showing general morphology of female pectines:

A. *Leiurus quinquestriatus* (reconstructed)

B. *Compsobuthus werneri*

C. *Orthochirus innesi*

f = fulcra, **mgl** = marginal lamellae, **mdl** = median lamellae, **pt** = pectinal teeth.

Morphological characters of pectines of female *Orthochirus innesi*

The pecten of female *Orthochirus innesi* (Fig. 3C) consists of three marginal lamellae, seven median lamellae, a row of 13-14 semicircular fulcra; each fulcrum bears number of trichobothria (Fig. 4E), usually 2-3, and a row of elliptical denticles or pectinal teeth (14-15), each denticle bears 300-350 peg sensilla (Fig. 5E). Each sensillum is being 2.5 μm in diameter and 2.1 μm long with a tip slit of 1.2 μm (Table 1 & Fig. 6E).

Discussion

Three genera, *Leiurus*, *Compsobuthus* and *Orthochirus* represent the scorpion fauna of the studied area. This study revealed that, the collected numbers of female individuals were higher than male in the first two genera. No male individuals were collected for *Orthochirus*. Absence of male *O. innesi* opens a suggestion that this species may be parthenogenetic, as this phenomenon was reported in some scorpion species (Makioka and Koike, 1984 & 1985; El-Bakary, 1986).

Pectines have been utilized as a taxonomic character of scorpions (Brown, 1996), while their function has evoked great disputation. The location of pecten near the genital aperture and book lungs, their contact with substrate during walking and response of scorpions to ground vibrations have led to some speculation on pectinal function. Savory (1977) and other authors regarded them as having been derived from the gill lamellae of the Xiphosurida.

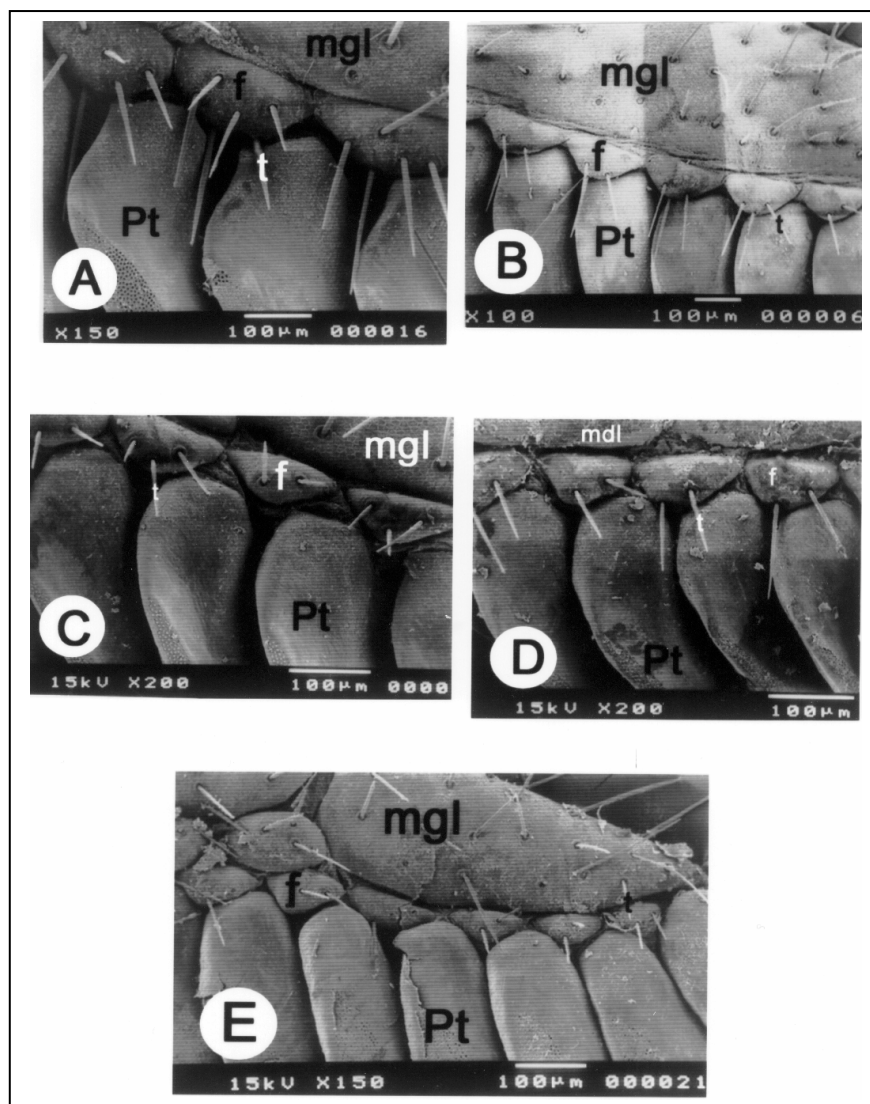


Fig. 4: Scanning electron micrographs showing fulcra of different pectines of the three scorpion species with variable numbers of trichobothria:

A. ♂, **B.** ♀ *Leiurus quinquestriatus* **C.** ♂, **D.** ♀ *Compsobuthus werneri*
E. ♀ *Orthochirus innesi*. **f** = fulcra, **mgl** = marginal lamellae,
mdl = median lamellae, **pt** = pectinal teeth, **t** = trichobothria.

Pecten comb is consisting of three marginal lamellae and a variable number of median lamellae, fulcra and pectinal teeth. The number of marginal lamellae is fixed for the studied scorpion species while the number of median lamellae is the same for *C. werneri* and *O. innesi*. Morphological differences of the pectines are found in the three studied species and also among male and female within the same species. These differences are in the number and shape of pectinal teeth, number of fulcra, number of trichobothria and number of peg sensilla.

Stahnke (1970) mentioned that the pectinal teeth number ranged from three (Genus *Euscorpium*) to more than forty in some buthids. According to Hjelle (1990), median lamellae or fulcra are absent in some taxa.

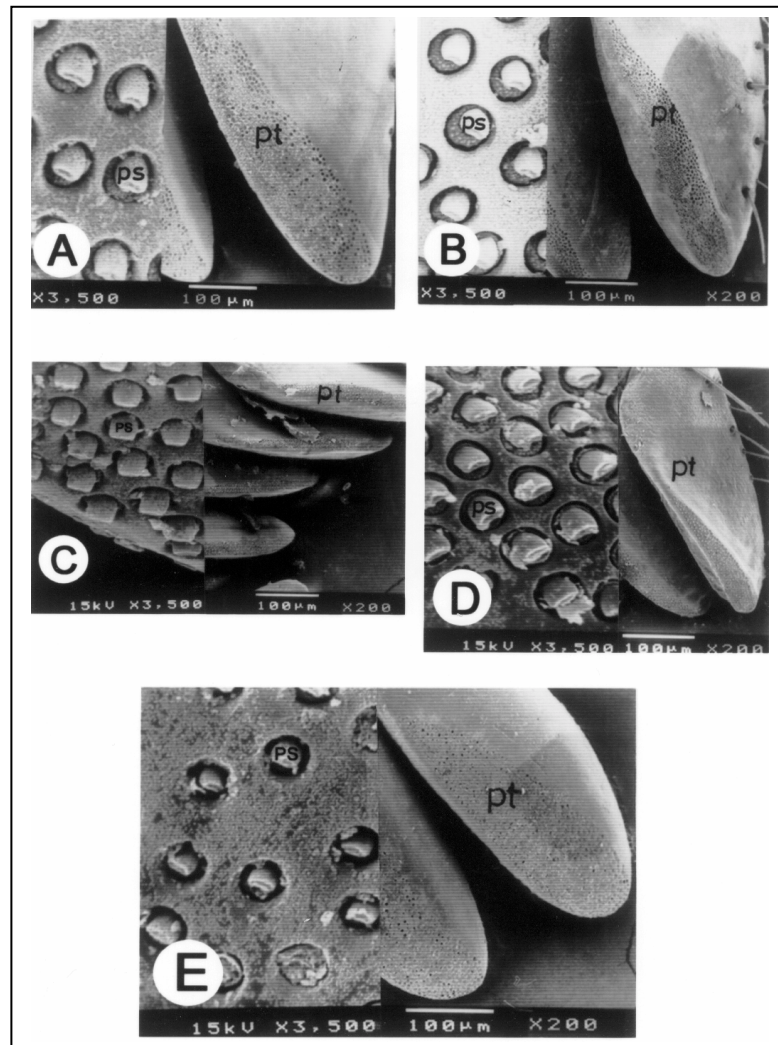


Fig. 5: Scanning electron micrographs showing pectinal teeth (denticles) of different pectines of the three scorpion species (right) and enlarged portion of their ventral surfaces showing peg sensilla (left):

A. ♂, **B.** ♀ *Leirus quinquestriatus* **C.** ♂, **D.** ♀ *Compsobuthus werneri*
E. ♀ *Orthochirus innesi*. **ps** = peg sensilla, **pt** = pectinal teeth.

In *L. quinquestriatus* sexual dimorphism in the pecten morphology is more pronounced than in *C. werneri*. Generally, the number of pectinal teeth is greater in males than in females in the present studied species. Brown (1996) recorded variations in pecten teeth counts within individuals of the scorpion *Centruroides vittatus*. Francke and Jones (1982) also recorded these asymmetric counts in

Centruroides gracilis where symmetric and asymmetric counts were equally frequent. Also they recorded pecten teeth count difference between males and females, while Lourenço (1981) recorded no intersexual variation in *Tityus cambridgei*.

On the anteroventral margin of each pectinal tooth a patch of sensory structures, the peg-shaped sensilla, are found (sensilla basiconia of Sreenivasa Reddy, 1959; sensory pegs of Carthy, 1966 & 1968). Carthy found that each pectinal tooth of *L. quinquestriatus* contains about 400 sensilla but the present study recorded about 1000-1200 sensilla on each tooth. This variation may be referred to the difference in scorpion length or age where these two factors affected the number of sensilla (Swoveland, 1978). The male pectines of *L. quinquestriatus* and *C. weneri* were found to have a greater number of peg sensilla, and sensory hairs (Trichobothria) than females. In *L. quinquestriatus* the peg sensilla of males are longer and wider than those of females, while they are nearly equal in both male and female of *C. weneri*.

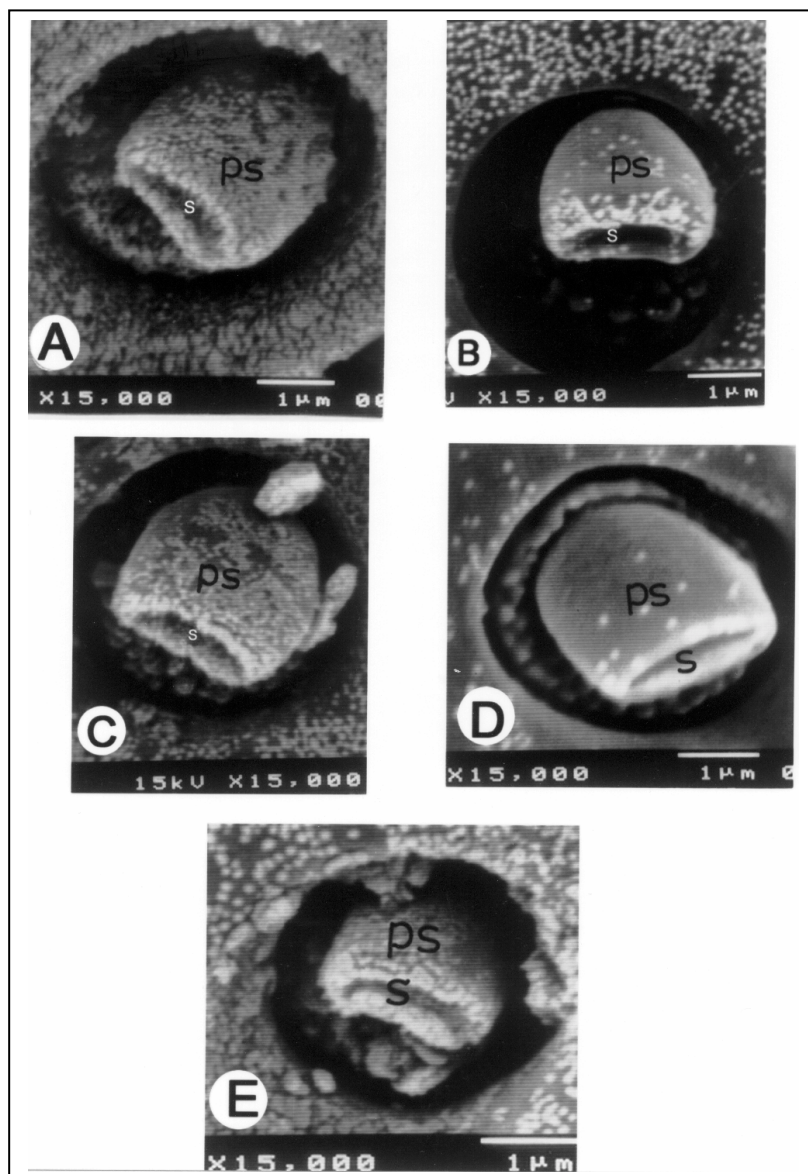


Fig. 6: Scanning electron micrographs showing peg sensilla of different pectines of the three scorpion species:

A. ♂, **B.** ♀ *Leiurus quinquestriatus* **C.** ♂, **D.** ♀ *Compsobuthus weneri*
E. ♀ *Orthochirus innesi*. **ps** = peg sensilla, **s** = slit.

Swoveland (1978) recorded that in chactoid species, females have longer peg sensilla than males. The peg sensilla appear to be broadly sensitive to odours and tastes (Gaffin and Brownell, 1997). It seems that the large number of male peg sensilla (twice or more than in female) enable them to recognize female hormones, pecten serves as chemoreceptor, which produced by a gland associated with the anus at the end of metasoma (Sissom, 1990). It is well known that scorpions are solitary non-social animals which live apart. The detection of female hormone by male pecten was recorded in many species (Bücherl, 1956; Alexander, 1959 and Probst, 1972). Male can detect female hormone at a distance of 1-8 meter (Polis and Sissom, 1990). Pecten seems to be important for discriminating surface texture (Abushama, 1964; Carthy, 1966 & 1968 and Boyden, 1978). This may also explain the sexual dimorphism; male pectines must be highly sensitive and well equipped for selecting suitable site for spermatophore deposition.

The morphological characters of pectinal teeth of the three studied species also indicated, that the pectines of *L. quinquestriatus* and *C. werneri* are closer in shape than that of *O. innesi*.

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Photography of Arachnids, A simple technique

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To get a picture of alive arachnid is sometimes problematic, especially scorpions and sun-spiders (solpugids). Hence, I tried a simple method to prevent the scorpion from going away when I try to get its photograph, avoiding to use a glass sided terrarium, such a method which yields numerous noisy light reflections.

The new method is summarized in having two water barriers around the central place where the scorpion is temporarily staying.

As shown in (Fig. 1), the target of photography (the arachnid) will be on sand substratum filling a plastic dish (19 cm diameter x 1.5 cm height of edge) in the centre of a rounded tray (32 cm diam. x 3 cm h.) filled with water. This tray is in the centre of another larger rounded tray (60 cm diam. x 4 cm h.) also filled with water.

The arachnid must be transferred to the middle of the central dish to be in open cage and ready for photography using a flash or two with the camera. After that, the responses of different kinds of arachnids are different too. The following examples were encountered during application of this method:

I. Order Scorpionida (Scorpions):

1. *Scorpio* sp. (Fig. 3a,b) quickly moved towards the edge of the dish and touched water with pedipalps to stop and to move backwards, then to run in another direction to find again the edge and to repeat the behaviour. The same behaviour had been repeated few times. Then, the scorpion learned (?) to avoid the edge and to quietly move in the median area of the dish. Even after exciting the scorpion by touching its prosoma with a forceps, it did not violently behave.
2. *Leiurus quinquestriatus* fast ran towards the edge to fall in water and continued to enter the second water barrier when I seized it with a forceps to return it to the median area where it began the escape again twice. After the third trial, it moved in the area of the dish to come near water but not to fall again.
3. *Nebo hierichonticus* quickly ran towards the edge of the dish to fall in water and to hide below the edge and to stay there undisturbed under water. After a few minutes, I had to pick it up from water. It again repeated the same behaviour. It was difficult to keep it in the suitable place for photography after it discovered that water shelter. That reminded me of a bedouin in St. Catherine, southern Sinai, who told me in 1989 that "the blue scorpion lives in water". *N. hierichonticus* is black but it has a blue tincture which appears when photographed. Also, this new technique proved to me that it likes water and that it may hide in nature in water streams or wells.

II. Order Solpugida (Sun-spiders):

- *Galeodes* sp. (Fig. 2) very quickly ran to fall in water. It could not continue running like *L. quinquestriatus* because of its hairy covering which turned it to a ball of soaked wool. It tried again to escape after being dry but every time the water prevented it. Then, it quietly behaved to make it possible to get its photograph. It is preferred not to disturb a sun-spider during photography. This pushes it to jerk endlessly towards water.

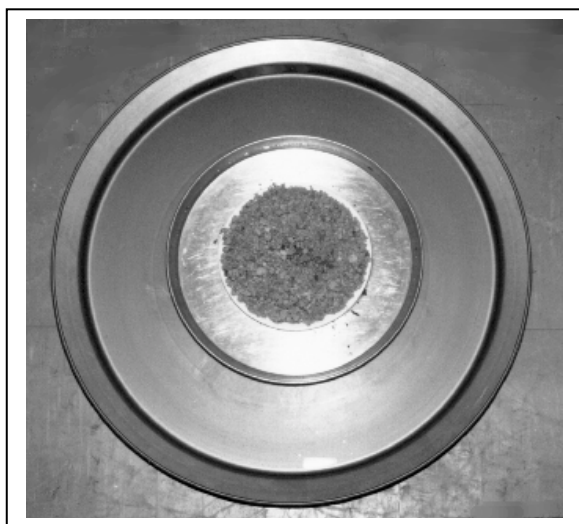


Fig. 1. Photography stage.



Fig. 2. *Galeodes* sp.

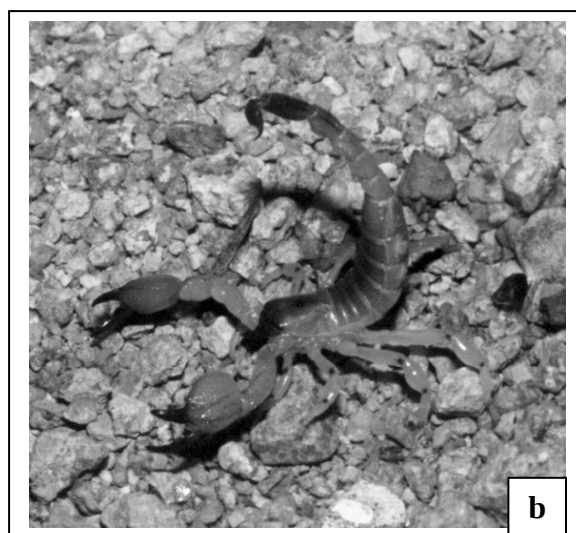
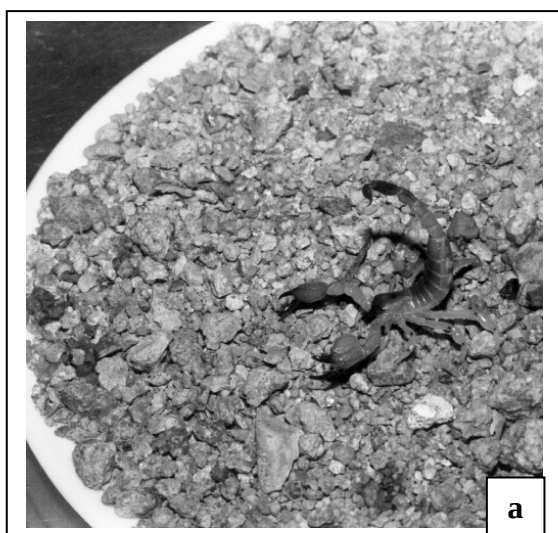


Fig. 3a,b. *Scorpio* sp. in the middle of the photography stage.
